PATENT

ATTORNEY DOCKET NO.: AGX-14-CPA-RCE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Gat, et al.	)	
	)	Examiner: Nguyen, Kiet
Serial No.: 09/226,396	)	
	)	Art Unit: 2881
Filed: January 6, 1999	)	
	)	Deposit Acct. No.: 04-1403
Title: Heating Device for Heating Semiconductor Wafers in Thermal Processing Chambers	)	

Commissioner of Patents
P. O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Applicants submit herewith the following Brief on Appeal in accordance with 37 C.F.R. § 1.192:

1. Real Party in Interest

The real party in interest in this matter is Mattson Technology, Inc., which acquired rights in the application through Steag RTP Systems, Inc.

2. Related Appeals and Interferences

There are no other appeals or interferences known to the Applicants or the Applicants' legal representative which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

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3. Status of the Claims

Claims 32-33, 35-56 and 58-73 are currently pending in the present application, including independent claims 32, 43, 51 and 60. All of the pending claims are attached hereto as Exhibit A. In the final Office Action dated July 2, 2003, the Examiner rejected claims 32-33, 35-56 and 58-59 under 35 U.S.C. §103(a) solely in view of U.S. Patent No. 5,367,606 to Moslehi, et al and allowed claims 60-73.

4. Status of Amendments

All amendments filed by Applicants since filing a Request for Continuing Examination (RCE) on February 11, 2003 have been entered into the record by the Examiner.

5. Summary of the Invention

A. General

The present invention is generally directed to an apparatus for heat treating semiconductor wafers. As stated in the "Background of the Invention" section of the present application, it is desirable to control the rate at which a semiconductor wafer is heated so as to prevent temperature gradients within the wafer (App. pg. 2, lines 10-20). Specifically, semiconductor wafer edges tend to have cooling and heating rates that are different than the wafer center (App. pg. 2, lines 22-26). One challenge in semiconductor wafer manufacturing is to uniformly heat wafers and control the process without a complex or expensive system.

The apparatus of the present invention includes a plurality of light energy sources and at least one tuning device that are used to heat semiconductor wafers. The light energy sources may be, for instance, a plurality of lamps which form overlapping heating zones on a wafer being heated. The light energy sources may be, for instance, tungsten-halogen lamps. The lamps can be substantially vertically oriented with respect to a wafer being heated, or can be oriented horizontally.

The tuning device, as defined in the claims, can comprise a variety of different devices such as a light energy source spaced from at least one optical element that comprises at least one focusing lens (claim 32), a laser diode (claim 43), a generally

vertically oriented lamp device positioned amongst horizontally oriented light energy sources (claim 51) or a prismatic surface (claim 60). The tuning devices allow fine adjustments to be made to the wafer irradiance distribution pattern in order to heat the wafer under a more controlled temperature regime and more uniformly (App. pg. 5, lines 13-19).

As shown in Figure 1 of the present application, the apparatus 10 can include a thermal processing chamber 12 adapted to contain a semiconductor wafer 14, a substrate holder 15, a cooling conduit 16, gas inlet 18, gas outlet 20, and a heating device 22 (App. pg. 12, lines 1-6, 12-16, and 20-23).

B. Heating Device

The processing chamber 12, shown in Figure 1, includes a heating device 22. The heating device may include an assembly of light energy sources or lamps 24, positioned in any location to heat different zones of the wafer (App. pg. 13, lines 10-18). Also, the semiconductor wafer 14, substrate holder 15, or the light energy lamps 24 may be rotated by a rotation mechanism 21 to promote uniform wafer heating (App. pg. 12, line 35-pg. 13, line 1 and pg. 5, lines 6-11). In semiconductor manufacturing, lamps are preferable over other heating devices, such as electrical elements or conventional furnaces. Lamps provide instantaneous energy through short and controlled start-up periods and are able to stop heating abruptly. A power controller 25 may be used to decrease or increase the light energy emitted by the lamps. (App. pg. 13, lines 19-30). As shown in Figure 2, lamps 24 may be arranged in concentric rings where each serves to heat a separate radial zone on a wafer (App. pg. 17, lines 20-22).

C. Active Tuning Devices

As shown in Figure 2 of the present invention, the heating device 22 also includes at least one tuning device 40 positioned amongst the light energy sources 24 and configured to change the irradiance distribution of the light energy sources for improved uniform wafer heating. Active tuning devices are designed to emit controlled and focused amounts of light energy onto particular locations of a semiconductor wafer. (App. pg. 17, lines 25-33).

Active tuning devices may take various forms as described on page 18 of the present application. For instance, in one embodiment, the tuning device can be a laser diode. In an alternative embodiment, as shown in Figure 3, the tuning device may be a light energy source in operative association with at least one focusing lens. The light energy source and focusing lens may be mounted to a support structure that is adjustable for focusing light energy onto a particular and desired location of a wafer.

In still another alternative embodiment, the tuning device may be a vertically oriented lamp, while the heating device may comprise a plurality of horizontally oriented lamps.

As shown in Figure 1, the present invention may also include radiation sensing devices 27 that monitor the temperature of a wafer 14 during heating (App. pg. 14, lines 19-22). Thermocouples or other temperature sensing devices may be used instead of radiation sensors (App. pg. 16, lines 15-18). The apparatus 10 also includes a filter 32 to prevent the radiation sensing devices from detecting thermal radiation emitted by the lamps 24 and to prevent contamination of the chamber (App. pg. 15, lines 22-25).

The present invention, as shown in Figure 1, further includes a system controller 50 to calculate the wafer temperature and a lamp power controller 25 to control the amount of thermal energy emitted by the lamps 24 (App. pg. 16, lines 15, 22-35). The system controller 50 can also control the tuning devices 40 independently or dependently with the lamps 24 (App. pg. 19, lines 1-10).

Heating configurations made according to the present invention are particularly well-suited for efficiently and uniformly heating a semiconductor wafer during processing. In particular, a plurality of lamps in combination with one or more tuning devices and a control system ensure that semiconductor wafers are uniformly heated.

D. Passive Tuning Devices

Instead of or in addition to active tuning devices, the system of the present invention may also include passive tuning devices. The passive tuning devices are also used to adjust and vary the irradiance distribution of the heating lamps in a manner that enhances wafer temperature uniformity. One embodiment of a system using passive tuning devices is illustrated in Figure 4. The tuning devices contain a ruled prismatic

surface that is designed to reflect light energy in a desired manner (App. pg. 20, lines 33-35 and App. pg. 21, lines 1-12).

6. Summary of the Issues

I. Are claims 32-33, 35-56 and 58-59 unpatentable under 35 U.S.C. § 103(a) in view of U.S. Patent No. 5,367,606 to Moslehi, et al.?

7. Grouping of the Claims

The claims are grouped according to the independent claims on which they depend; thus, the separate groups include claims 32-33 and 35-42, claims 43-50, and claims 51-56 and 58-59.

8. Argument

Currently, claims 32-33, 35-56 and 58-73 are pending in the present application, including independent claims 32, 43, 51 and 60. All of the claims are directed to an apparatus for heat treating semiconductor wafers. The apparatus includes a thermal processing chamber, adapted to contain a semiconductor wafer and a heating device in communication with the thermal processing chamber for heating the semiconductor wafer. The heating device includes a plurality of light energy sources configured to emit light energy onto the semiconductor wafer and at least one tuning device positioned amongst the light energy sources. The tuning device is configured to operate in conjunction with the light energy sources to change the irradiance distribution of the light energy sources in a manner for more uniformly heating the semiconductor wafer.

In the Final Office Action, all rejected claims were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,367,606 to Moslehi, et al. The appropriate standard when analyzing the claims and the cited prior art under § 103 is stated in Merck & Co. Inc. v Biocraft Laboratories Inc.:

> The proper focus of an obviousness inquiry is on whether the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art. 10 USPQ2d 1843, 1846 (Fed. Cir. 1989).

As is well known, the Examiner bears the burden of presenting a *prima facie* case of obviousness in rejecting the claims under 35 U.S.C. § 103. "A *prima facie* case of obviousness is established when the teachings from the prior art itself would appear to have suggested the claimed subject matter to a person of ordinary skill in the art." In re Bell, 991 F.2d 781, 782, 26 USPQ2d 1529, 1531 (Fed. Cir. 1993). The mere fact that the prior art may be modified in the manner suggested by the Examiner does not in and of itself render the claims obvious unless the prior art provided some suggestion, motivation or incentive for the modification. In re Fritch, 972 F.2d 1260, 1266, 23 USPQ2d 1780, 1783-84 (Fed. Cir. 1992). Here, as explained below, Applicants submit that the Examiner has failed to establish a *prima facie* case of obviousness.

Moslehi, et al. is directed to a multi-zone illuminator for processing semiconductors with embedded process control sensors. The illuminator includes lamps, a reflector plate, and a means for adjusting the space between the wafer and the reflector plate and the wafer and the lamps. As stated in Column 2, lines 12-14, the lamps are arranged in a plurality of concentric circular zones for generating and directing optical energy. The apparatus in Moslehi, et al. further includes dummy lamps that are identical to the heating lamps except that their output radiation is isolated from the wafer. (See Col. 6, lines 49-51). As stated in Column 6, lines 54-57, "the purpose of the dummy lamps is to measure the light modulation depth...for the purpose of precise pyrometry-based temperature measurement."

When compared to the presently pending claims, Moslehi, et al. not only fails to disclose or suggest a tuning device positioned amongst a plurality of light energy sources, but also fails to disclose or suggest the specific tuning devices required by each of the independent claims. The following addresses each group of claims separately, the relevance of Moslehi, et al., and the Examiner's arguments as they apply to each.

I. **Claims 32-33 and 35-42 are not rendered obvious under 35 U.S.C. § 103(a) in view of U.S. Patent No. 5,367,606 to Moslehi, et al.**

Independent claim 32 is directed to an apparatus for heat treating semiconductor wafers and includes a thermal processing chamber in communication with a heating device. The heating device includes a plurality of light energy sources and at least one tuning device positioned amongst the light energy sources that is configured to emit focused amounts of light energy. In claim 32, the tuning device comprises a light energy source spaced from at least one optical element that comprises at least one focusing lens. The optical element is configured to focus and direct light energy being emitted by the light energy source onto the semiconductor wafer at a particular location.

As opposed to the above-identified claims, Moslehi, et al. fails to disclose or suggest a tuning device positioned amongst a plurality of light energy sources and further fails to disclose or suggest a light energy source spaced from at least one optical element comprising at least one focusing lens, as required by claim 32. In the Office Action dated November 20, 2001, the Examiner admitted that Moslehi, et al. did not disclose a focusing lens. The Examiner, however, stated:

> Using the focusing lens is considered to be obvious variation in design, since the focusing lens is well known in the art and in the optical system, thus would have been obvious to one skilled in the art to use the focusing lens in the Moslehi et al. apparatus for focusing the light beam on the wafer.

The Examiner provided no evidence whatsoever, however, for the assertion that a focusing lens "is considered to be obvious variation in design". In fact, the above statement is no more than an unsupported conclusion--not a reason upon which to base the rejection.

Since Moslehi, et al. fails to disclose or suggest a tuning device positioned amongst a plurality of light energy sources and fails to disclose or suggest the use of a light energy source in combination with a focusing lens as a tuning device, Applicants respectfully submit that the claims as presently pending patentably define over the cited reference.

II. Claims 43-50 are not rendered obvious under 35 U.S.C. § 103(a) in view of U.S. Patent No. 5,367,606 to Moslehi, et al.

Independent claim 43, similar to independent claim 32, is directed to an apparatus that includes a heating device in communication with a thermal processing chamber. The heating device includes a plurality of light energy sources and at least one tuning device. In independent claim 43, the tuning device comprises a laser diode that emits light energy onto a determined location of the semiconductor wafer.

As opposed to claims 43 through 50, Moslehi, et al. fails to disclose or suggest a tuning device positioned amongst a plurality of light energy sources and further fails to disclose a tuning device comprising a laser diode as specified in claim 43. In the Office Action dated November 20, 2001, the Examiner admitted that Moslehi, et al. did not disclose a laser diode. The Examiner, however, stated:

> Using the laser diode is considered to be obvious variation in design, since the laser diode is well known in the art for producing light, thus would have been obvious to one skilled in the art to use the laser diode in the Moslehi et al. apparatus for heating the wafer.

Here again, the Examiner provided no evidence whatsoever, however, for the assertion that a laser diode "is considered to be obvious variation in design". In fact, the above statement is no more than an unsupported conclusion--not a reason upon which to base the rejection.

Since Moslehi, et al. fails to disclose or suggest a tuning device positioned amongst a plurality of light energy sources and fails to disclose or suggest the use of a laser diode as a tuning device, Applicants respectfully submit that claims 43 through 50 as presently pending patentably define over the cited reference.

III. Claims 51-56 and 58-59 are not rendered obvious under 35 U.S.C. § 103(a) in view of U.S. Patent No. 5,367,606 to Moslehi, et al.

Independent claim 51 is directed to an apparatus for heat treating semiconductor wafers that includes a heating device in communication with a thermal processing chamber. The heating device includes a plurality of light energy sources and at least one tuning device. In claim 51, the light energy sources are horizontally oriented with

respect to the semiconductor wafer for forming an irradiance distribution across a surface of the wafer. The tuning device, on the other hand, comprises a lamp device that is generally vertically oriented with respect to the semiconductor wafer. The tuning device emits localized and focused light energy in a manner for more uniformly heating the semiconductor wafer.

As opposed to the invention defined in claims 51 through 56 and 58 through 59, Moslehi, et al. (1) fails to disclose or suggest a tuning device positioned amongst a plurality of light energy sources; (2) fails to disclose or suggest a plurality of light energy sources that are horizontally oriented with respect to a semiconductor wafer; and (3) fails to disclose or suggest the combination of horizontally oriented light energy sources in conjunction with a tuning device that comprises a vertically oriented lamp device.

In the Office Action dated March 11, 2003, the Examiner responded by stating:

> Orienting horizontally the plurality of light energy sources with respect to the wafer is also considered to be obvious variation in design, since both orienting vertically and horizontally light sources with respect to the wafer have the same results for heating the wafer, thus would have been obvious to one skilled in the art to orient horizontally the plurality of light energy sources with respect to the wafer in the Moslehi et al. apparatus for uniformly heating the wafer.

The Examiner, however, failed to present any evidence to show that it would have been obvious to not only horizontally orient the plurality of light energy sources present in the Moslehi, et al. apparatus but to also include at least one tuning device that comprises a vertically oriented lamp device. Absent any evidence to support the above assertions, Applicants submit that claims 51 through 56 and 58 through 59 patentably define over Moslehi, et al.

In conclusion, it is respectfully submitted that the claims are patentably distinct over the prior art of record and that the present application is in complete condition for allowance. As such, Applicants respectfully request issuance of a patent.

2/2/04
Date

Respectfully submitted,

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EXHIBIT A

32. An apparatus for heat treating semiconductor wafers comprising:

a thermal processing chamber adapted to contain a semiconductor wafer; and

a heating device in communication with said thermal processing chamber for heating a semiconductor wafer in said chamber, said heating device comprising:

(a) a plurality of light energy sources configured to emit light energy onto said semiconductor wafer, said light energy sources being positioned so as to form an irradiance distribution across a surface of said semiconductor wafer; and

(b) at least one tuning device positioned amongst said light energy sources, said tuning device being configured to emit focused amounts of light energy, said tuning device comprising a light energy source spaced from at least one optical element comprising at least one focusing lens, said optical element being configured to focus and direct light energy being emitted by said light energy source onto said semiconductor wafer at a particular location in a manner for more uniformly heating said semiconductor wafer.

33. An apparatus as defined in claim 32, further comprising a substrate holder for holding said semiconductor wafer, said substrate holder being configured to rotate said wafer.

35. An apparatus as defined in claim 32, wherein said tuning device is mounted in a movable support structure.

36. An apparatus as defined in claim 35, wherein said support structure comprises a tiltable lever arm.

37. An apparatus as defined in claim 32, wherein said light energy source and said at least one focusing lens are mounted on a support structure, said support structure being movable for directing light energy emitted from said light energy source onto a determined location on said semiconductor wafer.

38. An apparatus as defined in claim 37, wherein the said support structure comprises a tiltable lever arm.

39. An apparatus as defined in claim 32, further comprising:

at least one temperature sensing device for sensing the temperature of said semiconductor wafer at least one location; and

a controller in communication with said at least one temperature sensing device and at least one of said light energy sources, said controller being configured to control the amount of light energy being emitted by said light energy sources in response to temperature information received from said at least one temperature sensing device.

40. An apparatus as defined in claim 32, wherein said apparatus contains at least three of said tuning devices.

41. An apparatus as defined in claim 39, wherein said controller is configured to control the amount of light energy being emitted by said tuning device independently of said plurality of light energy sources.

42. An apparatus as defined in claim 32, wherein said plurality of light energy sources are horizontally oriented with respect to said semiconductor wafer.

43. An apparatus for heat treating semiconductor wafers comprising:

a thermal processing chamber adapted to contain a semiconductor wafer; and

a heating device in communication with said thermal processing chamber for heating a semiconductor wafer in said chamber, said heating device comprising:

(a) a plurality of light energy sources configured to emit light energy into said semiconductor wafer, said light energy sources being positioned so as to form an irradiance distribution across a surface of said wafer; and

(b) at least one tuning device comprising a laser diode, said laser diode emitting light energy onto a determined location on said semiconductor wafer in order to more uniformly heat said semiconductor wafer.

44. An apparatus as defined in claim 43, further comprising a substrate holder for holding said semiconductor wafer, said substrate holder being configured to rotate said wafer.

45. An apparatus as defined in claim 43, wherein said tuning device is mounted in a movable support structure.

46. An apparatus as defined in claim 43, wherein said tuning device is adjustable for directing light energy being emitted from said at least one laser diode onto a determined location on said semiconductor wafer in order to more uniformly heat said semiconductor wafer.

47. An apparatus as defined in claim 43, further comprising:

at least one temperature sensing device for sensing the temperature of said semiconductor wafer at least one location; and

a controller in communication with said temperature sensing device with at least certain of said light energy sources, and with said tuning device, said controller being configured to control the amount of light energy being emitted by said light energy sources and said tuning device in response to temperature information received from said temperature sensing device.

48. An apparatus as defined in claim 47, wherein said controller is configured to control the amount of light energy being emitted by said at least one tuning device independently of said light energy sources.

49. An apparatus as defined in claim 43, wherein said apparatus contains at least three of said tuning devices.

50. An apparatus as defined in claim 43, wherein said plurality of light energy sources are horizontally oriented with respect to said semiconductor wafer.

51. An apparatus for heat treating semiconductor wafers comprising:

a thermal processing chamber adapted to contain a semiconductor wafer; and

a heating device in communication with said thermal processing chamber for heating a semiconductor wafer contained in said chamber, said heating device comprising:

(a) a plurality of light energy sources configured to emit light energy onto said semiconductor wafer, said light energy sources being positioned so as to form an irradiance distribution across a surface of said wafer, the light energy sources being horizontally oriented with respect to the semiconductor wafer, each of said light energy sources comprising a first lamp device; and

(b) at least one tuning device positioned amongst said light energy sources, said tuning device being generally vertically oriented with respect to the semiconductor wafer and comprising a second lamp device, wherein said first lamp device is different from said second lamp device, the tuning device emitting localized and focused light energy in a manner for more uniformly heating the semiconductor wafer.

52. An apparatus as defined in claim 51, further comprising a substrate holder for holding said semiconductor wafer, said substrate holder being configured to rotate said wafer.

53. An apparatus as defined in claim 51, wherein said tuning device is mounted in a movable support structure.

54. An apparatus as defined in claim 51, further comprising:

at least one temperature sensing device for sensing the temperature of said semiconductor wafer at least one location; and

a controller in communication with said temperature sensing device with at least certain of said light energy sources, and with said tuning device, said controller being configured to control the amount of light energy being emitted by said light energy sources and said tuning device in response to temperature information received from said temperature sensing device.

55. An apparatus as defined in claim 54, wherein said controller is configured to control the amount of light energy being emitted by said at least one tuning device independently of said light energy sources.

56. An apparatus as defined in claim 51, wherein said apparatus contains at least three of said tuning devices.

58. An apparatus as defined in claim 51, wherein said tuning device comprises a laser diode.

59. An apparatus as defined in claim 58, wherein said plurality of light energy sources comprises tungsten halogen lamps.

60. An apparatus for heat treating semiconductor wafers comprising:

a thermal processing chamber adapted to contain a semiconductor wafer; and

a heating device in communication with said thermal processing chamber for heating a semiconductor wafer in said chamber, said heating device comprising:

(a) a plurality of light energy sources configured to emit light energy onto said semiconductor wafer, said light energy sources being positioned so as to form an irradiance distribution across a surface of said semiconductor wafer; and

(b) at least one tuning device comprising a prismatic surface, said tuning device positioned amongst said light energy sources, said tuning device being configured to direct light energy being emitted by said light energy sources onto said semiconductor wafer in a manner for more uniformly heating said semiconductor wafer.

61. An apparatus as defined in claim 60, further comprising a substrate holder for holding said semiconductor wafer, said substrate holder being configured to rotate said wafer.

62. An apparatus as defined in claim 60, wherein said tuning device is mounted in a movable support structure.

63. An apparatus as defined in claim 62, wherein said support structure comprises a tiltable lever arm.

64. An apparatus as defined in claim 60, wherein said prismatic surface has a fixed pitch and a fixed facet angle.

65. An apparatus as defined in claim 60, wherein said prismatic surface has a fixed pitch with a variable facet angle.

66. An apparatus as defined in claim 60, wherein the height of said optical element is adjustable with respect to said light energy sources.

67. An apparatus as defined in claim 60, wherein said apparatus contains at least three of said tuning devices.

68. An apparatus as defined in claim 60, further comprising:

at least one temperature sensing device for sensing the temperature of said semiconductor wafer at at least one location; and

a controller in communication with said at least one temperature sensing device and at least one of said light energy sources, said controller being configured to control the amount of light energy being emitted by said light energy sources in

response to temperature information received from said at least one temperature sensing device.

69. An apparatus as defined in claim 60, wherein said prismatic surface comprises a ruled prismatic surface.

70. An apparatus as defined in claim 60, wherein said tuning device reflects light energy being emitted by said light energy sources.

71. An apparatus as defined in claim 60, wherein said tuning device refracts light energy being emitted by said light energy sources.

72. An apparatus as defined in claim 60, wherein said prismatic surface is made from a highly reflective material having a reflectivity of at least 0.9 at a wavelength being emitted by said light energy sources.

73. An apparatus as defined in claim 60, wherein said prismatic surface comprises a diffuse surface for reflecting and scattering light energy.

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The apparatus of the present invention includes a plurality of light energy sources and at least one tuning device that are used to heat semiconductor wafers. The light energy sources may be, for instance, a plurality of lamps which form overlapping heating zones on a wafer being heated. The light energy sources may be, for instance, tungsten-halogen lamps. The lamps can be substantially vertically oriented with respect to a wafer being heated, or can be oriented horizontally.

The tuning device, as defined in the claims, can comprise a variety of different devices such as a light energy source spaced from at least one optical element that comprises at least one focusing lens (claim 32), a laser diode (claim 43), a generally

vertically oriented lamp device positioned amongst horizontally oriented light energy sources (claim 51) or a prismatic surface (claim 60). The tuning devices allow fine adjustments to be made to the wafer irradiance distribution pattern in order to heat the wafer under a more controlled temperature regime and more uniformly (App. pg. 5, lines 13-19).

As shown in Figure 1 of the present application, the apparatus 10 can include a thermal processing chamber 12 adapted to contain a semiconductor wafer 14, a substrate holder 15, a cooling conduit 16, gas inlet 18, gas outlet 20, and a heating device 22 (App. pg. 12, lines 1-6, 12-16, and 20-23).

B. Heating Device

The processing chamber 12, shown in Figure 1, includes a heating device 22. The heating device may include an assembly of light energy sources or lamps 24, positioned in any location to heat different zones of the wafer (App. pg. 13, lines 10-18). Also, the semiconductor wafer 14, substrate holder 15, or the light energy lamps 24 may be rotated by a rotation mechanism 21 to promote uniform wafer heating (App. pg. 12, line 35-pg. 13, line 1 and pg. 5, lines 6-11). In semiconductor manufacturing, lamps are preferable over other heating devices, such as electrical elements or conventional furnaces. Lamps provide instantaneous energy through short and controlled start-up periods and are able to stop heating abruptly. A power controller 25 may be used to decrease or increase the light energy emitted by the lamps. (App. pg. 13, lines 19-30). As shown in Figure 2, lamps 24 may be arranged in concentric rings where each serves to heat a separate radial zone on a wafer (App. pg. 17, lines 20-22).

C. Active Tuning Devices

As shown in Figure 2 of the present invention, the heating device 22 also includes at least one tuning device 40 positioned amongst the light energy sources 24 and configured to change the irradiance distribution of the light energy sources for improved uniform wafer heating. Active tuning devices are designed to emit controlled and focused amounts of light energy onto particular locations of a semiconductor wafer. (App. pg. 17, lines 25-33).

Active tuning devices may take various forms as described on page 18 of the present application. For instance, in one embodiment, the tuning device can be a laser diode. In an alternative embodiment, as shown in Figure 3, the tuning device may be a light energy source in operative association with at least one focusing lens. The light energy source and focusing lens may be mounted to a support structure that is adjustable for focusing light energy onto a particular and desired location of a wafer.

In still another alternative embodiment, the tuning device may be a vertically oriented lamp, while the heating device may comprise a plurality of horizontally oriented lamps.

As shown in Figure 1, the present invention may also include radiation sensing devices 27 that monitor the temperature of a wafer 14 during heating (App. pg. 14, lines 19-22). Thermocouples or other temperature sensing devices may be used instead of radiation sensors (App. pg. 16, lines 15-18). The apparatus 10 also includes a filter 32 to prevent the radiation sensing devices from detecting thermal radiation emitted by the lamps 24 and to prevent contamination of the chamber (App. pg. 15, lines 22-25).

The present invention, as shown in Figure 1, further includes a system controller 50 to calculate the wafer temperature and a lamp power controller 25 to control the amount of thermal energy emitted by the lamps 24 (App. pg. 16, lines 15, 22-35). The system controller 50 can also control the tuning devices 40 independently or dependently with the lamps 24 (App. pg. 19, lines 1-10).

Heating configurations made according to the present invention are particularly well-suited for efficiently and uniformly heating a semiconductor wafer during processing. In particular, a plurality of lamps in combination with one or more tuning devices and a control system ensure that semiconductor wafers are uniformly heated.

D. Passive Tuning Devices

Instead of or in addition to active tuning devices, the system of the present invention may also include passive tuning devices. The passive tuning devices are also used to adjust and vary the irradiance distribution of the heating lamps in a manner that enhances wafer temperature uniformity. One embodiment of a system using passive tuning devices is illustrated in Figure 4. The tuning devices contain a ruled prismatic

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The claims are grouped according to the independent claims on which they depend; thus, the separate groups include claims 32-33 and 35-42, claims 43-50, and claims 51-56 and 58-59.

8. Argument

Currently, claims 32-33, 35-56 and 58-73 are pending in the present application, including independent claims 32, 43, 51 and 60. All of the claims are directed to an apparatus for heat treating semiconductor wafers. The apparatus includes a thermal processing chamber, adapted to contain a semiconductor wafer and a heating device in communication with the thermal processing chamber for heating the semiconductor wafer. The heating device includes a plurality of light energy sources configured to emit light energy onto the semiconductor wafer and at least one tuning device positioned amongst the light energy sources. The tuning device is configured to operate in conjunction with the light energy sources to change the irradiance distribution of the light energy sources in a manner for more uniformly heating the semiconductor wafer.

In the Final Office Action, all rejected claims were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,367,606 to Moslehi, et al. The appropriate standard when analyzing the claims and the cited prior art under § 103 is stated in Merck & Co. Inc. v Biocraft Laboratories Inc.:

> The proper focus of an obviousness inquiry is on whether the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art. 10 USPQ2d 1843, 1846 (Fed. Cir. 1989).

As is well known, the Examiner bears the burden of presenting a *prima facie* case of obviousness in rejecting the claims under 35 U.S.C. § 103. "A *prima facie* case of obviousness is established when the teachings from the prior art itself would appear to have suggested the claimed subject matter to a person of ordinary skill in the art." In re Bell, 991 F.2d 781, 782, 26 USPQ2d 1529, 1531 (Fed. Cir. 1993). The mere fact that the prior art may be modified in the manner suggested by the Examiner does not in and of itself render the claims obvious unless the prior art provided some suggestion, motivation or incentive for the modification. In re Fritch, 972 F.2d 1260, 1266, 23 USPQ2d 1780, 1783-84 (Fed. Cir. 1992). Here, as explained below, Applicants submit that the Examiner has failed to establish a *prima facie* case of obviousness.

Moslehi, et al. is directed to a multi-zone illuminator for processing semiconductors with embedded process control sensors. The illuminator includes lamps, a reflector plate, and a means for adjusting the space between the wafer and the reflector plate and the wafer and the lamps. As stated in Column 2, lines 12-14, the lamps are arranged in a plurality of concentric circular zones for generating and directing optical energy. The apparatus in Moslehi, et al. further includes dummy lamps that are identical to the heating lamps except that their output radiation is isolated from the wafer. (See Col. 6, lines 49-51). As stated in Column 6, lines 54-57, "the purpose of the dummy lamps is to measure the light modulation depth...for the purpose of precise pyrometry-based temperature measurement."

When compared to the presently pending claims, Moslehi, et al. not only fails to disclose or suggest a tuning device positioned amongst a plurality of light energy sources, but also fails to disclose or suggest the specific tuning devices required by each of the independent claims. The following addresses each group of claims separately, the relevance of Moslehi, et al., and the Examiner's arguments as they apply to each.

I. **Claims 32-33 and 35-42 are not rendered obvious under 35 U.S.C. § 103(a) in view of U.S. Patent No. 5,367,606 to Moslehi, et al.**

Independent claim 32 is directed to an apparatus for heat treating semiconductor wafers and includes a thermal processing chamber in communication with a heating device. The heating device includes a plurality of light energy sources and at least one tuning device positioned amongst the light energy sources that is configured to emit focused amounts of light energy. In claim 32, the tuning device comprises a light energy source spaced from at least one optical element that comprises at least one focusing lens. The optical element is configured to focus and direct light energy being emitted by the light energy source onto the semiconductor wafer at a particular location.

As opposed to the above-identified claims, Moslehi, et al. fails to disclose or suggest a tuning device positioned amongst a plurality of light energy sources and further fails to disclose or suggest a light energy source spaced from at least one optical element comprising at least one focusing lens, as required by claim 32. In the Office Action dated November 20, 2001, the Examiner admitted that Moslehi, et al. did not disclose a focusing lens. The Examiner, however, stated:

> Using the focusing lens is considered to be obvious variation in design, since the focusing lens is well known in the art and in the optical system, thus would have been obvious to one skilled in the art to use the focusing lens in the Moslehi et al. apparatus for focusing the light beam on the wafer.

The Examiner provided no evidence whatsoever, however, for the assertion that a focusing lens "is considered to be obvious variation in design". In fact, the above statement is no more than an unsupported conclusion--not a reason upon which to base the rejection.

Since Moslehi, et al. fails to disclose or suggest a tuning device positioned amongst a plurality of light energy sources and fails to disclose or suggest the use of a light energy source in combination with a focusing lens as a tuning device, Applicants respectfully submit that the claims as presently pending patentably define over the cited reference.

II. Claims 43-50 are not render d obvious under 35 U.S.C. § 103(a) in view of U.S. Patent No. 5,367,606 to Moslehi, et al.

Independent claim 43, similar to independent claim 32, is directed to an apparatus that includes a heating device in communication with a thermal processing chamber. The heating device includes a plurality of light energy sources and at least one tuning device. In independent claim 43, the tuning device comprises a laser diode that emits light energy onto a determined location of the semiconductor wafer.

As opposed to claims 43 through 50, Moslehi, et al. fails to disclose or suggest a tuning device positioned amongst a plurality of light energy sources and further fails to disclose a tuning device comprising a laser diode as specified in claim 43. In the Office Action dated November 20, 2001, the Examiner admitted that Moslehi, et al. did not disclose a laser diode. The Examiner, however, stated:

> Using the laser diode is considered to be obvious variation in design, since the laser diode is well known in the art for producing light, thus would have been obvious to one skilled in the art to use the laser diode in the Moslehi et al. apparatus for heating the wafer.

Here again, the Examiner provided no evidence whatsoever, however, for the assertion that a laser diode "is considered to be obvious variation in design". In fact, the above statement is no more than an unsupported conclusion--not a reason upon which to base the rejection.

Since Moslehi, et al. fails to disclose or suggest a tuning device positioned amongst a plurality of light energy sources and fails to disclose or suggest the use of a laser diode as a tuning device, Applicants respectfully submit that claims 43 through 50 as presently pending patentably define over the cited reference.

III. Claims 51-56 and 58-59 are not rendered obvious under 35 U.S.C. § 103(a) in view of U.S. Patent No. 5,367,606 to Moslehi, et al.

Independent claim 51 is directed to an apparatus for heat treating semiconductor wafers that includes a heating device in communication with a thermal processing chamber. The heating device includes a plurality of light energy sources and at least one tuning device. In claim 51, the light energy sources are horizontally oriented with

respect to the semiconductor wafer for forming an irradiance distribution across a surface of the wafer. The tuning device, on the other hand, comprises a lamp device that is generally vertically oriented with respect to the semiconductor wafer. The tuning device emits localized and focused light energy in a manner for more uniformly heating the semiconductor wafer.

As opposed to the invention defined in claims 51 through 56 and 58 through 59, Moslehi, et al. (1) fails to disclose or suggest a tuning device positioned amongst a plurality of light energy sources; (2) fails to disclose or suggest a plurality of light energy sources that are horizontally oriented with respect to a semiconductor wafer; and (3) fails to disclose or suggest the combination of horizontally oriented light energy sources in conjunction with a tuning device that comprises a vertically oriented lamp device.

In the Office Action dated March 11, 2003, the Examiner responded by stating:

> Orienting horizontally the plurality of light energy sources with respect to the wafer is also considered to be obvious variation in design, since both orienting vertically and horizontally light sources with respect to the wafer have the same results for heating the wafer, thus would have been obvious to one skilled in the art to orient horizontally the plurality of light energy sources with respect to the wafer in the Moslehi et al. apparatus for uniformly heating the wafer.

The Examiner, however, failed to present any evidence to show that it would have been obvious to not only horizontally orient the plurality of light energy sources present in the Moslehi, et al. apparatus but to also include at least one tuning device that comprises a vertically oriented lamp device. Absent any evidence to support the above assertions, Applicants submit that claims 51 through 56 and 58 through 59 patentably define over Moslehi, et al.

In conclusion, it is respectfully submitted that the claims are patentably distinct over the prior art of record and that the present application is in complete condition for allowance. As such, Applicants respectfully request issuance of a patent.

2/2/04
Date

Respectfully submitted,

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EXHIBIT A

32. An apparatus for heat treating semiconductor wafers comprising:

a thermal processing chamber adapted to contain a semiconductor wafer; and

a heating device in communication with said thermal processing chamber for heating a semiconductor wafer in said chamber, said heating device comprising:

(a) a plurality of light energy sources configured to emit light energy onto said semiconductor wafer, said light energy sources being positioned so as to form an irradiance distribution across a surface of said semiconductor wafer; and

(b) at least one tuning device positioned amongst said light energy sources, said tuning device being configured to emit focused amounts of light energy, said tuning device comprising a light energy source spaced from at least one optical element comprising at least one focusing lens, said optical element being configured to focus and direct light energy being emitted by said light energy source onto said semiconductor wafer at a particular location in a manner for more uniformly heating said semiconductor wafer.

33. An apparatus as defined in claim 32, further comprising a substrate holder for holding said semiconductor wafer, said substrate holder being configured to rotate said wafer.

35. An apparatus as defined in claim 32, wherein said tuning device is mounted in a movable support structure.

36. An apparatus as defined in claim 35, wherein said support structure comprises a tiltable lever arm.

37. An apparatus as defined in claim 32, wherein said light energy source and said at least one focusing lens are mounted on a support structure, said support structure being movable for directing light energy emitted from said light energy source onto a determined location on said semiconductor wafer.

38. An apparatus as defined in claim 37, wherein the said support structure comprises a tiltable lever arm.

39. An apparatus as defined in claim 32, further comprising:

at least one temperature sensing device for sensing the temperature of said semiconductor wafer at least one location; and

a controller in communication with said at least one temperature sensing device and at least one of said light energy sources, said controller being configured to control the amount of light energy being emitted by said light energy sources in response to temperature information received from said at least one temperature sensing device.

40. An apparatus as defined in claim 32, wherein said apparatus contains at least three of said tuning devices.

41. An apparatus as defined in claim 39, wherein said controller is configured to control the amount of light energy being emitted by said tuning device independently of said plurality of light energy sources.

42. An apparatus as defined in claim 32, wherein said plurality of light energy sources are horizontally oriented with respect to said semiconductor wafer.

43. An apparatus for heat treating semiconductor wafers comprising:

a thermal processing chamber adapted to contain a semiconductor wafer; and

a heating device in communication with said thermal processing chamber for heating a semiconductor wafer in said chamber, said heating device comprising:

(a) a plurality of light energy sources configured to emit light energy into said semiconductor wafer, said light energy sources being positioned so as to form an irradiance distribution across a surface of said wafer; and

(b) at least one tuning device comprising a laser diode, said laser diode emitting light energy onto a determined location on said semiconductor wafer in order to more uniformly heat said semiconductor wafer.

44. An apparatus as defined in claim 43, further comprising a substrate holder for holding said semiconductor wafer, said substrate holder being configured to rotate said wafer.

45. An apparatus as defined in claim 43, wherein said tuning device is mounted in a movable support structure.

46. An apparatus as defined in claim 43, wherein said tuning device is adjustable for directing light energy being emitted from said at least one laser diode onto a determined location on said semiconductor wafer in order to more uniformly heat said semiconductor wafer.

47. An apparatus as defined in claim 43, further comprising:

at least one temperature sensing device for sensing the temperature of said semiconductor wafer at least one location; and

a controller in communication with said temperature sensing device with at least certain of said light energy sources, and with said tuning device, said controller being configured to control the amount of light energy being emitted by said light energy sources and said tuning device in response to temperature information received from said temperature sensing device.

48. An apparatus as defined in claim 47, wherein said controller is configured to control the amount of light energy being emitted by said at least one tuning device independently of said light energy sources.

49. An apparatus as defined in claim 43, wherein said apparatus contains at least three of said tuning devices.

50. An apparatus as defined in claim 43, wherein said plurality of light energy sources are horizontally oriented with respect to said semiconductor wafer.

51. An apparatus for heat treating semiconductor wafers comprising:

a thermal processing chamber adapted to contain a semiconductor wafer; and

a heating device in communication with said thermal processing chamber for heating a semiconductor wafer contained in said chamber, said heating device comprising:

(a) a plurality of light energy sources configured to emit light energy onto said semiconductor wafer, said light energy sources being positioned so as to form an irradiance distribution across a surface of said wafer, the light energy sources being horizontally oriented with respect to the semiconductor wafer, each of said light energy sources comprising a first lamp device; and

(b) at least one tuning device positioned amongst said light energy sources, said tuning device being generally vertically oriented with respect to the semiconductor wafer and comprising a second lamp device, wherein said first lamp device is different from said second lamp device, the tuning device emitting localized and focused light energy in a manner for more uniformly heating the semiconductor wafer.

52. An apparatus as defined in claim 51, further comprising a substrate holder for holding said semiconductor wafer, said substrate holder being configured to rotate said wafer.

53. An apparatus as defined in claim 51, wherein said tuning device is mounted in a movable support structure.

54. An apparatus as defined in claim 51, further comprising:

at least one temperature sensing device for sensing the temperature of said semiconductor wafer at least one location; and

a controller in communication with said temperature sensing device with at least certain of said light energy sources, and with said tuning device, said controller being configured to control the amount of light energy being emitted by said light energy sources and said tuning device in response to temperature information received from said temperature sensing device.

55. An apparatus as defined in claim 54, wherein said controller is configured to control the amount of light energy being emitted by said at least one tuning device independently of said light energy sources.

56. An apparatus as defined in claim 51, wherein said apparatus contains at least three of said tuning devices.

58. An apparatus as defined in claim 51, wherein said tuning device comprises a laser diode.

59. An apparatus as defined in claim 58, wherein said plurality of light energy sources comprises tungsten halogen lamps.

60. An apparatus for heat treating semiconductor wafers comprising:

a thermal processing chamber adapted to contain a semiconductor wafer; and

a heating device in communication with said thermal processing chamber for heating a semiconductor wafer in said chamber, said heating device comprising:

(a) a plurality of light energy sources configured to emit light energy onto said semiconductor wafer, said light energy sources being positioned so as to form an irradiance distribution across a surface of said semiconductor wafer; and

(b) at least one tuning device comprising a prismatic surface, said tuning device positioned amongst said light energy sources, said tuning device being configured to direct light energy being emitted by said light energy sources onto said semiconductor wafer in a manner for more uniformly heating said semiconductor wafer.

61. An apparatus as defined in claim 60, further comprising a substrate holder for holding said semiconductor wafer, said substrate holder being configured to rotate said wafer.

62. An apparatus as defined in claim 60, wherein said tuning device is mounted in a movable support structure.

63. An apparatus as defined in claim 62, wherein said support structure comprises a tiltable lever arm.

64. An apparatus as defined in claim 60, wherein said prismatic surface has a fixed pitch and a fixed facet angle.

65. An apparatus as defined in claim 60, wherein said prismatic surface has a fixed pitch with a variable facet angle.

66. An apparatus as defined in claim 60, wherein the height of said optical element is adjustable with respect to said light energy sources.

67. An apparatus as defined in claim 60, wherein said apparatus contains at least three of said tuning devices.

68. An apparatus as defined in claim 60, further comprising:

at least one temperature sensing device for sensing the temperature of said semiconductor wafer at at least one location; and

a controller in communication with said at least one temperature sensing device and at least one of said light energy sources, said controller being configured to control the amount of light energy being emitted by said light energy sources in

response to temperature information received from said at least one temperature sensing device.

69. An apparatus as defined in claim 60, wherein said prismatic surface comprises a ruled prismatic surface.

70. An apparatus as defined in claim 60, wherein said tuning device reflects light energy being emitted by said light energy sources.

71. An apparatus as defined in claim 60, wherein said tuning device refracts light energy being emitted by said light energy sources.

72. An apparatus as defined in claim 60, wherein said prismatic surface is made from a highly reflective material having a reflectivity of at least 0.9 at a wavelength being emitted by said light energy sources.

73. An apparatus as defined in claim 60, wherein said prismatic surface comprises a diffuse surface for reflecting and scattering light energy.